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ranged as replicas of commonplace social situations conducive to cultural production. Since cultural phenomena were actually brought about in the experiments and not merely simulated, the miniature histories appear to be operational replicas. The matter of these particular replicas working outside of the laboratory has not been established.

But the experiments do raise questions as to the actual workings of culture in history. Our most disturbing discovery was the creativity of isolated groups. The stimulation and novelty of experience in open social settings did not increase cultural creativity in the experiments. The experimental demonstration of the coincidence of social closure with cultural invention poses the problem of the extent of their association in history. There are plausible examples of socially restricted creativity in schools of art and thought, in golden ages and recurrent clusterings of all sorts of distinguished achievement. But the great example of mobile and cosmopolitan urban populations having made the most of cultural change runs counter to our experimental results. We should hesitate to extend these results without qualification to a general interpretation of all cultural accomplishment. However, our results do give reason to question any bland presumption that social mobility leads inevitably to cultural creativity. We should now be more careful to search for explicit circumstances under which either isolation or mobility may contribute to the production of culture.

DIFFUSION IS PREDICTABLE: TESTING PROBABILITY MODELS FOR LAWS OF INTERACTION *

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WHAT FACTORS AFFECT DIFFUSION? THE DIMENSIONAL CANDIDATES

THE Air Force has dropped several billion leaflets in wartime—with effects that are not precisely known. It will be responsible for further leaflet drops in future conflicts. It needed research, therefore, on how to maximize the diffusion of leaflet messages and compliance with their instructions by the target populations. It wanted to learn the generalizable and manipulatable conditions for predicting and producing diffusion and compliance. This leaflet project on message diffusion offered the Public Opinion Laboratory resources for exploring its dimensional analysis and the interactance hypotheses part of it, through controlled experiments.

Message diffusion is but a one-way person-to-person form of interaction. Message diffusion is, furthermore, an observable and experimentable sub-form of social or cultural diffusion in general. Our interactance formula,[1] or general model, for any single kind of group behavior-in-context analyzes human interacting into six dimensions or classes of factors. The simple group behavior of spreading an attribute (defined as any all-or-none characteristic) was here studied as an example of a unified field of social

* Revised version of paper read at the American Sociological Society meetings, September, 1954.

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[1] S. C. Dodd, "The Interactance Hypothesis—A Gravity Model Fitting Physical Masses and Human Groups," *American Sociological Review,* 15 (April, 1950), pp. 245–256. The fuller development of dimensional analysis in the social sciences, of which Project Revere was an item, may be found in the author's *Dimensions of Society,* New York: Macmillan, 1942; and *Systematic Social Science,* Seattle: University Bookstore, 1947. The details of the researches reviewed here may be found in the 44 published articles (bibliography on request).

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forces.[2] This field was factored into the six general dimensions of (1) the *behavior* of (2) *people* in (3) *time* and (4) *space* when internally stimulated or (5) *"motivated"* and externally (6) *stimulated* in specified ways.

The criterion behavior to be predicted was the *diffusing* of a leaflet message—usually dropped from airplanes. A secondary criterion was the *compliance* by the public with the leaflet's instructions to fill out and mail back a postage-free tracer stub attached to every leaflet. Diffusion was measured, either in polls of probability samples or by mail-backs, as the per cent of persons knowing the message at any one time. The all-or-none (1) act of telling the message orally or passing on a leaflet and the all-or-none (2) react of hearing (and remembering) it constituted a "tell-hear" interact.

A prime methodological interest of this research was in the homogeneity of these six classes of factors or "sectors" in the human sciences. Is each class sufficiently homogeneous so that principles found to hold for one variable or index in a class will hold for the whole class? This is often the case for the three elementary sectors of space, time, and number of people, but is it the case for the compound sectors of behavior, motivations, and stimulations?

WHAT CURVES MEASURE DIFFUSION? THE EMPIRICAL FITS

The chief question throughout Project Revere was at first: What is the chief relation between diffusion and each factor alone? This breaks down into three sub-questions: What is the *shape* of the curve relating them? How *closely* does that curve fit the data? What is the *statistical significance,* or probability of recurrence, of that closeness of the fit? The answers to these questions for the six interactance factors will be summarized in turn as far as Project Revere found answers.

The Activity Factor in Diffusion. The diffusion index, defined as the proportion of message knowers in a population, developed the chief parameter of our models as a "potency" index. The "potency" was defined as the acts-per-actor or new tellings-per-teller. A potent message is an oft told one; an impotent message is seldom retold. The potency rate or speed (acts per actor in a period, A/PT) became the most useful predictive index of diffusion. The acceleration of the potency rate in a population defined the *social force* exerted by the leaflet operator. The potency of any message depends not only on the message content but also on the population and situation. The same content could have different potencies in war or peacetime, in enemy or friendly populations, etc.

This potency rate should itself become predictable. But our attempts to predict it from attitude tests and ratings were not clean enough to yield any firm generalizations beyond the situations studied.

The Population Factor in Diffusion. How, next, did diffusion depend on the number of persons in the target population? What was the shape of the curve relating the diffusion index to the size of the population in a series of towns? The answer seems to be a logarithmic curve in terms of absolute diffusion, or a hyperbola in terms of relative diffusion. (When the hyperbola is expressed in discrete units, it becomes the harmonic series or reciprocals of the natural numbers.) This was evidenced by a close fit ($r=.99$) but with statistically significant discrepancies (at the 5 per cent level) in one test on six towns ranging from 1,300 to 328,000 population. The harmonic model here accounted for 98 per cent ($=r^2$) of the variance of the data, but the remaining 2 per cent of discrepancy was apparently due to a systematic error in one town and was not attributable to sampling fluctuations. When one leaflet per person was evenly scattered by airplane at mid-day on each of these six towns, the number of mailbacks tended to increase with the size of town but with diminishing increments. This was a logarithmic relation of absolute diffusion to town size.

In these towns the more the people, the more the absolute response, but the less the relative response. The mailback per capita rate tended to vary inversely with the town's population. It dropped from 10 per cent in

[2] See S. C. Dodd, "A Theory for the Measurement of Some Social Forces," *Scientific Monthly,* 43 (July, 1936); "Standard Error of a Social Force," *Annals of Mathematical Statistics,* 7 (December, 1936).

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the smallest town to 3 per cent in the largest town several hundred times larger.

We hypothesize the following "overlaying" rationale towards explaining this diminishing returns trend: that as towns get larger, they generate more than proportionate *inter*stimulation per capita. The leaflet stimulation (being constant at one leaflet per person) would then shrink relatively to all the stimulation playing on each person. The diffusion response per capita would thus necessarily shrink as the towns enlarged. This overlaying explanation and alternative hypotheses can, we believe, be experimentally tested in further models designed to isolate them.

The Time Factor in Diffusion. How does the diffusing depend upon the time elapsed? The answer here with close and significant fits from a dozen tests was that, under conditions of steady and equal opportunities, the diffusion tended to grow in plurels in a decaying exponential or convex upward curve, and in groups in a linear logistic or S-shaped curve. In the experiments with cleanest controls, the correlation of model and uncumulated data exceeded .99 with discrepancies that were statistically nonsignificant at the 5 per cent level.

In a plurel, the reactors to the mass stimulation of leaflets falling from the sky reacted by picking up leaflets and reading them. This "physical diffusion," as we call it, grew deceleratingly. Its rate of growth waned as time passed, with fewer and fewer non-knowers left to pick up leaflets. Furthermore, the stimulation waned within the hours of one day, since leaflets were soon entirely removed from the streets. The children especially delighted in collecting them and even tried to sell them to our observers.

In a group, however, the interactors told or showed the message to each other. The S-shaped logistic curve of knowers rises slowly at first when there are few tellers active, then accelerates to its maximum slope when half the population know and half don't know, and then decelerates as the few non-knowers become harder and harder to find. This particular curve or probabilistic diffusion model is simply the cumulation in successive periods of the "most probable" increments. The logistic curve is thus the most probable growth curve for interaction in pairs in any large and homogeneous population of molecules, mice or men, wherever many independent influences determine the transfer of the attribute.

The Space Factor in Diffusion. How, next, did diffusing depend upon the distance intervening between tellers and hearers? The answer here is an harmonic or die-away curve observed in several tests with close and significant fits. The diffusing waned with distance. The further the message traveled, the fewer the people who knew it. The rule was: "Nearby, many hear; far off, few hear."

For example, in "Operation Coffee," one of the cleanest tests in Project Revere's twenty-seven diverse tests, the diffusion varied inversely with distance as follows. On a Monday morning, interviewers told a coffee slogan to a random 17 per cent of housewives in a town of 950 inhabitants. The housewives were further told that anyone knowing the coffee company's new slogan at a census of households on Wednesday would get a free pound of coffee. With this bait and with the mass media controlled, the slogan spread exclusively by word of mouth to 82 per cent of the housewives in forty-eight hours. Our interviews in the census traced all links including the interhome distances of each hearer and her teller. The distribution of these distances in 125 pairs of interactors fitted an harmonic curve with a closeness of fit correlation of .99 and with nonsignificant discrepancies by the chi square test at the 5 per cent level.

The explanatory rationale or preconditions for the inverse distance curve are fairly well known. They can be stated in differing terms such as Zipf's "least effort" explanation, a mathematical "random walk" explanation, a "counter-acting part of a constant whole" explanation, our geometric "radial zones" explanation, etc. Of these variant versions perhaps the radiant zones version is most universal as it explains the effect of distance, we believe, alike in Newton's law of gravity and in demographic gravitation or social diffusion from a point.

Briefly, suppose a particle (or person or any entity) has a constant amount of energy (or social influence of any one sort) which is equally likely to diffuse in any direction. Draw concentric zones of equal widths

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around the particle (zones in a volume, or in a plane, or along a line give the same result). The space in each zone can be proved geometrically to vary directly with its distance (radius) from the particle. Since the constant energy was assumed to diffuse evenly, it will become divided into smaller amounts per unit space the further out it goes. The energy per unit space at distance L will then be inversely proportional to L, i.e., it will vary as L^{-1}, which is the harmonic series. For simplest social diffusion, one assumes that the potency is unity and that the people are uniformly distributed in the area as in a homogeneous residential section of a large city. (Varying potencies and densities complicate the model, of course.) Then the proportion of people influenced in each zone will necessarily be inverse to that zone's distance from the origin point.

The Values or Motivational Factor in Diffusion. How did diffusing depend on the population's values (operationally defined as what pollees say they want)? The answer here is an indication of a linear relation but with loose and unsure fits and some ambiguous evidence too intricate to review here.

It seems to us that the values sector composed of all indices of human desiderata is still too internally diverse a class of variables to permit many generalizations about it from our few indices of unknown representativeness and when observed under incompletely specified situations. Much fuller search for the preconditions of valuing behavior is needed. (A comprehensive "valuance model or theory" aimed to fill this need is presented in Chapter 60 of *Revere Studies on Interaction.*)

The Stimulation Factor in Diffusion. Finally, how did diffusion depend on the strength of the stimulation (measured in per capita leaflets dropped)?

The answer is a logarithmic relation observed in two testings with close and significant fits. The public's response increased with the logarithm of the stimulus. Another way of stating this is: "To add a unit of response, multiply the stimulus by a constant." In eight roughly matched Washington towns, the leaflets per person were doubled at each step, starting the series with 1 for 4 persons, and ending with 32 per person. The response, measured by the per cent of people who heard the message, went up in about equal increments of 9 per cent for each doubling of the stimulation. This is the Weber-Fechner law in sensory psychology of individuals, found to hold in the cognitive responding of whole communities here. The closeness of fit correlation was .97. Thus, the logarithmic model or curve here accounted for 94 per cent of the variance of the data ($r^2=.94$). The remaining 6 per cent of unaccounted for variance may have been due to sampling fluctuations, since the chi square test showed these discrepancies from the log hypothesis to be not significant at the 5 per cent level.

Although this logarithmic relation had been predicted by publishing it earlier as an expectation, yet it is largely an empirical finding still with inadequate rationale. We expect that it will be reobserved whenever leaflets of any one kind in geometrically increasing numbers are dropped over matched towns in any culture. But exactly why this will be so, or how nearly so it is likely to be in new situations that differ in observable ways and degrees from those hitherto observed, we cannot yet say with confidence.[3]

Summary of the Factors of Diffusion. In summary, Project Revere found that interacting, when observed in its sub-form of message diffusing here, and under the probabilistic and other specified preconditions with each factor isolated in turn, tended to vary:

[3] The unusually close and significant tests of fit observed in the cleanest of our studies in Project Revere call for a footnote. Closeness of fit correlation coefficients exceeding r=.99 in uncumulated data and some of the other indices of fit seemed to us unbelievably high for sociological data. Since they recurred repeatedly, but in only our best controlled experiments, and after the possibility of computational errors, spurious r, too few degrees of freedom, etc. had been eliminated, we believe they accurately reflect the phenomena. We predict they will recur if observed under the unusually favorable methodological conditions of Project Revere, such as unusual resources in funds and authority, unusually clear-cut dimensional models to test, and unusually controllable stimuli and responses. Altogether we believe that Project Revere was a demonstration that the sociologist, if given research resources comparable to those given physicists, can increasingly produce results of comparable exactness and predictivity.

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1.* linearly with the earlier *acts* and *reacts* of telling and hearing (as a definitional result);
2.* linearly with the *values* or asserted wants of the target population (as an empiric finding in one study);
3.* linearly perhaps with certain *demographic and other conditions* (as hints of empiric findings when better tested);
4. harmonically with the *distance* the message travels (as a clear empiric and rational finding from several studies);
5.* harmonically (as to speed) with the *time* since it started, i.e., from a dated stimulus (as a general empiric and rational finding from a dozen studies);
6. logarithmically with the total *stimulation* in an unlimited range (as a clear empiric finding in two studies);
7. logarithmically with the *population* in town size (as an empiric tendency in one study);
8. exponentially with the *time, in plurels* (as a clear empiric and rational finding in two studies);
9. logistically with the *time, in groups* (as an empiric and rational finding in a dozen studies);
10.* harmonic exponentially with *time,* in plurels, if with a "dated" stimulus (as an empiric and rational finding in one study);
11.* harmonic logistically with *time,* in groups, if with a "dated" stimulus (as an empiric and rational finding in twelve studies);
12.* normally from *person to person* under multiple stimulation (as an indicated but not tested empiric and rational finding from several studies);
13.* log normally with *time,* under multiple and waning stimulation (as an indicated but untested empirical and rational finding from two studies).

Each of the above relations names a shape of curve which is specified exactly by its formula. The dimensional formulas specify only the *shape* of curve relating the predictive factor to the predicted diffusion. The statistical formulas also specify the *slope* and *location* of each curve within a family of shapes. The dimensional formulas specify only the basic variables and their exponents, neglecting the details of coefficients and addend parameters of the statistical formulas. The summary above, therefore, states the general findings relating diffusion to its contextual factors when stripped of detail peculiar to the particular indices and situations studied.

* The starred items are not discussed in this paper.

WHAT PRECONDITIONS EXPLAIN DIFFUSION? THE PROBABILITY HYPOTHESES

Four Criteria for Preconditions. The fits of curves to diffusion data in Project Revere were reviewed above, mostly at the empirical level. But scientists try to go deeper and develop hypotheses on the rational level. These state the preconditions for each empirically observed fit and so permit predicting its recurrence in new situations where those conditions exist.

In modeling we searched for conditions of greatest possible universality or invariance. We tried to state the necessary and sufficient preconditions in terms transcending differences in personality, social situation, or culture with which sociologists are so largely concerned. We even tried to transcend the social sciences and to state the conditions for any model in dimensional or mathematical terms, so as to be general to the content of any science. We used four criteria in looking for the ideal terms in which to formulate preconditions and models. The variables and the preconditions relating them should be so chosen and stated as to be: (1) reliably observable, (2) predictive, (3) universal, and, therefore, (4) culture-free.

We believe these four criteria have been achieved to a high degree in our diffusion models, by means of probability theory and our dimensional theory of actance. Let us see how.

First, we *defined* the diffusion variables as involving solely the three dimensions of *actors acting* in *time.*

In the case of diffusing messages, the actors are persons, the acts are tellings and hearings whose end product is the attribute "knowing the message" and the time is the period of diffusing. These basic variables or dimensions thus defined, whether for human or non-human diffusion, can be observed with suitable instruments, we submit, reliably, predictively, universally, and free of cultural differences.

Three Preconditions for Diffusion of an Attribute. Next we assumed just three culture-free preconditions among the dimen-

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sions of acts, people, and time. These conditions specified: (1) the number of attributes, whether 1 or more; (2) their distribution in the *population,* whether randomly, equally, or otherwise; (3) their distribution in *time,* whether steady, waning, waxing, or otherwise.

The normal probability curve assumes *many, random* acts in any time distribution. The exponential growth curve assumes *one random steady* act. The linear logistic growth curve assumes *one random steady pair* act. The italicized words in the last three sentences specify the necessary and sufficient social preconditions, or mathematical assumptions, under which the curves named will occur. We stress again that words such as "one," "many," "random," "steady," and "pair" are general to any field of science.

These behavioral preconditions of diffusing are expressed algebraically as the *assumptions.* From these the model proper, such as an algebraic formula or a geometric curve, is mathematically derived. This model is then hypothesized to fit the data—insofar as the data were actually conforming to the specified behavioral preconditions.

The fit does not check the derivation of the model from its assumptions and from the definitions of the variables, for that is a matter of logical and mathematical proof. *The indices of fit tell how fully and independently the behavioral preconditions, expressed mathematically as assumptions, may exist in the situation observed.*

The Randomness Precondition. The essential precondition in Project Revere models was randomness. The attribute was assumed to diffuse in chance-like or equally probable ways through the population. The models were probability structures. The problem of predicting the diffusing was reduced to observing or testing the preconditions—and eventually their preconditions in turn.

The preconditions of randomness are (roughly) *many, small, independent* influences or multiplex determiners, with none dominating. This implies a population that is homogeneous relative to the stimulation at issue or else one so heterogeneous that its many determiners are each a small share of the total. Thus, when a plane spreads leaflets evenly over a town, the distribution of that attribute (i.e., knowing the message) may be random insofar as many small different events (and only these) determine whether or not each particular person sees a leaflet. Then, from this random distribution as a baseline, single large determiners—such as being out-of-town, or being unable to read, or having children who delight in gathering leaflets—will produce measurable departures. The more fully the model includes such non-random factors also, the more fully it should fit the data, of course.

The reader is warned not to think of randomness as necessarily opposed to purposeful, planned, or customary behavior. It can be all of these simultaneously in a population. Acts that seem highly purposeful *to the individual,* such as the appointments he makes to see people in the course of a day, may also be randomlike *in the aggregate* in a large population. Person A's purposive meeting of B may have n different determiners. If each person, on the average, has m daily meetings and there are P persons in the population studied, then the total number of different influences determining meetings may be of the order of n x m x P. These influences may be in the millions but need only be a few hundred to result in distributions that fit random specifications closely. Even though some of the influences are correlated and so are not random (as when people in one place of work are more likely to see each other than to see other people), yet if there are many of these internally-correlated clusters (such as places of work), the aggregate effect can still approximate randomness. Random causation, in short, should be thought of not as irregular and chaotic but as *multiple and diverse* causation where every cause is but a small share of the total causation. Many bits of purposive behavior, if somewhat independent of each other, appear in the aggregate like random behavior. The "granules" in such "granular causation" may be regular, law abiding, predictable, and still behave randomly in toto if only the "granules" are sufficiently many, small, and different.

The chief social implication of randomness is that it is a highly "democratic" situation, as far as that term connotes equality of opportunity. If an attribute is randomly distributed in a population, it means that every person has a mathemati-

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cally equal opportunity to possess it. Thus, a well fitted logistic curve reflects a highly democratic equality of opportunity in respect to the interacting at issue. In this way modeling in social sciences can measure a community's degree of democracy in specified respects and guide the producing of such democracy. The three preconditions for the logistic growth curve—namely random, steady, pairings—can be less exactly restated in social terms as roughly a "democratic," "stable," "individualistic" community. But these terms have many other connotations unwanted here. The logistic curve's preconditions may be loosely stated as existing "Whenever an attribute spreads steadily from person to person with equal opportunity for everyone." Insofar as a community is "autocratic," "changing," and "organized," it may deviate from the logistic model—*provided* that the meanings of the respective words in quotes are limited to the opposite of "random, steady, pairing." Of course, the adjectives "democratic," etc. apply only in respect to the measured attribute. To be generally "democratic," etc. requires logistic fits for a representative sample of attributes in that culture. A composite logistic model could be constructed, we believe, to reflect how "democratic" "mature," and "uncentralized" a given community may be according to a set of representative and standardized indices which could then serve to define these concepts operationally.[4]

The words "probability" and "random" apply strictly to populations and not to persons. A probability is a proportion or arithmetic mean of an attribute. It is no more applicable to one person than is an "average for one person."

An Experiment Testing the Preconditions for the Logistic Model. Consider an example of a fully rationalized diffusion model. We have clarified the preconditions of the linear logistic model, namely, *steady pairing with equal opportunity* so fully now that they can be demonstrated in a classroom experiment on laws of social interaction. The discrete form of the logistic formula may be approximated as a continuous curve (as shown in Figure 1). This curve predicts how n messages will diffuse through the P persons in the class if the messages spread randomly and steadily by pairing. Figure 1 reports a classroom experiment. The resulting S-shaped growth curve should be within sampling limits of the curve expected by the logistic formula. The expected and uncumulated observations correlated .99 with the model. The small discrepancies were attributable to chance at the 5 per cent level. This shows that the preconditions of random, steady interacting existed solely and fully in this situation. This had been experimentally assured by having each of the twenty students tell his birth date as one message, thus starting twenty simultaneous "rumors." In each successive period of two minutes they paired off, thus interacting in pairs at a steady rate. They paired off randomly as assured by drawing their names in pairs from a well shuffled pack of cards. At each pair meeting each student copied into his record sheet all the "messages" on his partner's record sheet. This fixed the probability of "telling-if-met" (the k in Figure 1), or acts per actor and period, at unity for each message. At the end of each two-minute period a quick tally on the blackboard of the total number of messages known, as recorded on all record sheets, followed the expected curve with the closeness shown in Figure 1.

Here in the logistic model for simple group behavior the preconditions—random, steady, pairing—are stated in reliably observable, perfectly predictive, universal, and culture-free terms, as our criteria called for. Whatever the behavior; whoever the group; whenever and wherever they act; however the motivations, stimuli or physical causes may affect them; an S-shaped logistic growth curve will invariably occur *insofar as the*

[4] These social implications of randomness in simple group behavior may prove to be relatable to the randomness Ashby notes in the behavior of a brain. He developed a model for a brain or any system that has maximum probability of quick and effective adapting to *new* situations. This model for a brain seems also applicable to a human society as an entity that can learn or restabilize itself after unforeseen events (including destruction of a part of itself) as no current machine can do. This design for a brain has the four features of (1) many, (2) "part functions," and (3) "step functions," (4) all *randomly* combined. His lucid and brilliant argument, however speculative in spots, still seems to us well worth sociologists' studying and reducing to elemental experiments as we have tried to initiate in Project Revere. See Ashby, W. Ross, *Design for a Brain,* New York: Wiley, 1952, 260 pp.

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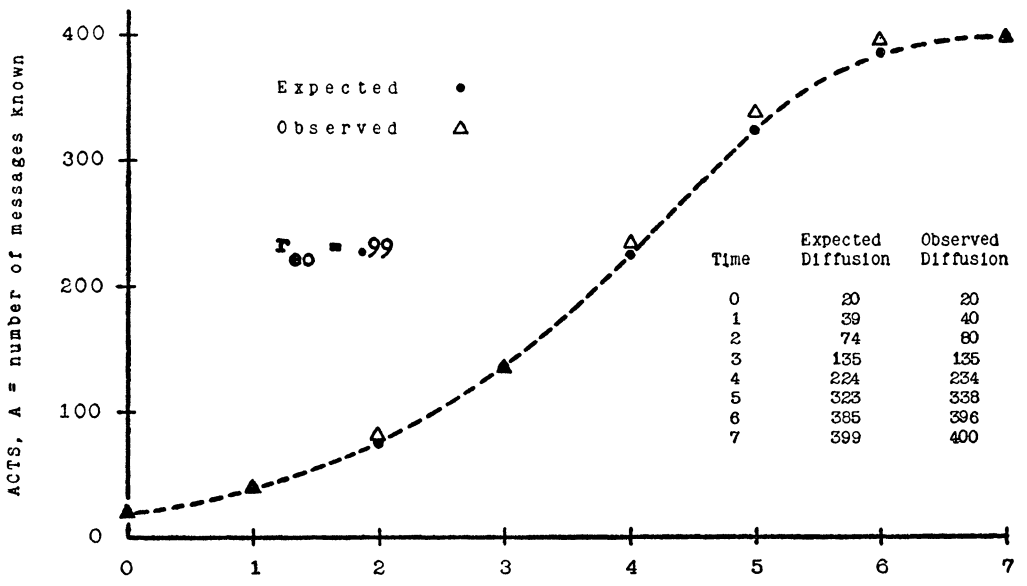
FIGURE 1. LOGISTIC MODELING FOR DIFFUSION

The *linear logistic law* of a joint probability cumulating in time demonstrated as a classroom experiment in human interaction.



Time	Expected Diffusion	Observed Diffusion
0	20	20
1	39	40
2	74	80
3	135	135
4	224	234
5	323	338
6	385	396
7	399	400

1 DEFINING the VARIABLES: a 3 dimensional closed system of *Acts* by *People* in *Time*

A = any all-or-none interact e.g. telling-and-hearing a message, $A = 1, o$

P = actors and reactors or interactors $p + q = 1$

e.g. p = proportion of knowers (interacted-on persons) q = nonknowers

T = number of time units T_i = an identified unit-period

2 ASSUMING the PRE-CONDITIONS:
- a. *Random* meetings e.g. pq by law of joint probability
- b. *Steady* acting e.g. 1 act per person in a period = "potency rate," k (= 1 here)

3 DEDUCING the MODEL: $\sum \Delta p_{i+1} = \sum k p_i q_i$ i.e. each period's increment, Δp, equals the previous period's variance, pq, or probability of knower meeting nonknower (times the activity rate, k, for the given situation)

4 TESTING EXPERIMENTALLY: 20 persons, each with a message, heard all 20 messages by random meetings in pairs in 8 minute-periods

5 TESTING the FIT STATISTICALLY: Expectations correlated with uncumulated observations at r = .99 Discrepancies were nonsignificant $\chi^2 = 5.640$ $.3 < p < .5$

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attribute spreads solely by random, steady, pairings. This principle applies to fruit flies in bottles, or to populations of nations, or to molecules of a gas, or to people telling a news item or communicating any new culture trait.

Whenever a theory in science analyzes any phenomena so fully as to permit synthesis of those phenomena, that field of science is maturing as an exact science. When social diffusion theory enables the scientist to measure, predict, and produce that diffusion to order under its specified preconditions, then this subfield of dimensional sociology seems to us to be "coming of age."

WHAT LAWS PREDICT DIFFUSING? THE MOMENT-POWERS MODEL

The empirical and rational inquiries on social diffusion sketched above led to formulating a system of candidate laws of social diffusion. This system is summarized in a simple formula or dimensional model described below. It requires only three letters to specify it. But first let us try to state as formal social laws of diffusion three cases of this summarizing dimensional model. Let the well-known normal probability curve, the decaying exponential curve, and the linear logistic curves be formally stated as examples with their social preconditions stated explicitly in reproducible form and in degrees in the "insofar as . . ." clauses.

The Normal Probability Law in Diffusing. Let the normal probability formula be stated in prose and in manipulatable terms as follows:

"Insofar as many, small, different attributes, each as likely to be present as absent, mix thoroughly in a population, their sum will tend to follow the binomial distribution and the normal bell-shaped distribution curve as their number gets large. (This curve is most simply defined by its differential equation $dp/dt=-kpt$ where dp/dt=the growth rate, k=a constant, p=the 'knower' proportion of the population, and t=time.)"

This normal model differs from the next two diffusion models to follow in this "power-moments" system in that: (a) it assumes t interchangeable attributes, whereas the exponential and logistic models assume but one attribute, and (b) it represents a growing series of complete distribution curves, not a growing series of frequencies of one curve.

It can be socially generated in a series of periods if mass media communicated a different item of news or advertising to a random half of the population on each of t successive days. At any t^{th} day a t^{th} order binomial distribution of items known to the people up to date would tend to result. The items must be independently communicated to be random, of course, regardless of whether they occurred on successive days or all at once. A single mass medium or monopoly of communicating introduces correlation and measurable loss of randomness as compared with having many different competing sources of information with none dominating the others.

The Decaying Exponential Law in Diffusing. "Insofar as all-or-none reacts of one kind in a plurel reacting to some common stimulation are distributed with somewhat equal opportunity for all the population and occur at a steady rate per person throughout a period, their sum will tend to follow the convex-upwards decaying exponential curve. (This is defined by its differential equation $dp/dt=kq$, where $q=1-p$.)"

This mathematical exponential law may be called a social law when the attribute diffuses among people. Its right to be called a scientific "law" stems from the mathematical certainty that it will invariably follow upon the specified preconditions. As usual throughout science and engineering, the question is to make sure in applying any law that its preconditions hold fully and solely in the situation at issue. If this applicability is in doubt, it may be less controversial to call it a "model" rather than a "law," since any model explicitly includes tests for its own applicability or "fit."

The Linear Logistic Law in Diffusing. "Insofar as all-or-none person-to-person interacts of one kind are distributed randomly, i.e., with fairly equal opportunity for everyone in a population, and the persons meet steadily in time, the sum of the interacts will tend to follow the S-shaped linear logistic curve. (This is defined by the differential equation $dp/dt=kpq$.)"

The simplest logistic curve is generated algebraically as the cumulation over t periods of the joint probability, pq, of

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knowers meeting non-knowers in each period (see Figure 1). It is socially generated by mixing knowers and non-knowers fully and freely, i.e., with equal opportunity for anyone to interact with anyone in each of the t periods.

Again, the "logistic model" connotes more than the "logistic law." For modeling explicitly connotes:

1. operational defining of the variables so as to be reliably reobservable;
2. explicit statement of the social preconditions as mathematical assumptions;
3. rigorous derivation of the formula or model proper exclusively from those definitions and assumptions;
4. specification of the experimental and statistical tests of fit.

A model is thus a theory spelled out in fully testable terms. It includes a system of hypotheses, where *"an hypothesis" is defined as a statement of an expected and testable relation among variables.* The primary hypothesis expects the whole model or set of preconditions to fit the data; the secondary hypotheses expect each precondition in isolation to hold and so to contribute to the total predicting.

The "Power-Moments" Model. In trying to synthesize the models, or operationally specified theory of diffusing (as developed in Project Revere), a brief dimensional formula was discovered. It is "the t^{th} power (t= time) of the m^{th} statistical moment of an attribute, A," namely:

$[A^m]^t$ the "moment-powers" model (in dimentional form)

The square brackets denote a dimensional formula, i.e., one dealing with basic variables and their exponents and neglecting details of coefficients (i.e., units) or addend parameters (i.e., origin points) in order to specify generic *shapes* of curves regardless of the local accident of their variant *slopes* and *locations.*

The behavioral meaning of this formula is: "Observe the attribute as some form of probability (specified below) in the population, then mix the people thoroughly t times to make that probability grow in time." The model thus describes the spreading of an attribute under probabilistic conditions.

When the observing is at one time only (so t=1), and as the exponent m varies, this model becomes the formula for simple probability (p), complementary probability (q), alternative probability (p+q), nul probability (o), joint probability (pq), a difference probability (q—p), etc.[5]

Next, when a time series or growth curve of dynamic probabilities is studied (so t>1), the moment-powers model describes as important special cases: (1) the diffusing of many items within each person of a population in a bell-shaped normal probability curve (developed from p+q), or (2) the diffusing of one item through a plurel in a convex upwards exponential curve (developed from q), or (3) the diffusing of one item through a group in an S-shaped logistic curve, (developed from pq), etc. This means that if one knows whether there are one or many attributes in the stable and relevantly homogeneous situation studied, and knows whether the attributes spread within persons, or in a plurel (as from mass media), or in dyadic groups (as from conversational pairs of persons), then he can predict respectively that the diffusion will grow in a normal, or exponential, or logistic curve. We further hypothesize that the third and fourth moments of the attribute growing in time will be found, when explored and tested, to describe diffusion in pro-con plurels and groups respectively.[6]

In conclusion, any reader interested in the unity of science should note that these diffusion models transcend social diffusion and describe simple forms of diffusion in any field of science. The moment-powers formula predicts the shape of the diffusion curve of any attribute(s) whatever through any population of entities if only the opportunities are sufficiently stable and equal for all entities.

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[5] For details see S. C. Dodd, "A Dimensional System of Diffusion Models," (to appear). A paper read at AAAS meetings, December, 1954.

[6] A more inclusive "power formula" for diffusion was developed by adding a script, a, for the number of attributes to the moment-powers formula. (See footnote 5.) This becomes a "conic powers" formula which as m becomes 0, —1, —2 defines respectively linear, logarithmic and harmonic or hyperbolic diffusion curves. Thus this versatile "power formula" includes both the "moment powers" and the "conic powers" in its families of diffusion curves. According as the four corner scripts in this formula vary, it becomes the harmonic, logarithmic, linear, parabolic, normal, exponential, logistic, or other common type of simple curve. All these curves were observed under specifiable conditions in Project Revere but can only be noted here in passing.

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